UNIVERSITY OF PENNSYLVANIA

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RICHARD S. SCHULTZ

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IN PSYCHOLOGY
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PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
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THE RELATION OF MAZE ADAPTABILITY, MAZE LEARNING, AND GENERAL INTELLIGENCE

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The general purpose of this investigation was to study a number of factors related to maze learning.[1] In particular, it was concerned with two problems: (1) the relation of general intelligence to ability in solving a maze problem and in maze learning; and (2) the relation of the ability to *solve* a maze problem to the ability to *learn* a maze problem.

This investigation differs from previous studies in its emphasis on the relation of adaptive capacity to maze learning. It attempts to obtain a measure of motor adaptive capacity as well as of motor learning in the same task.

Following earlier studies, a general intelligence test is used as one expression of adaptive capacity. But, in addition, another expression of adaptability is obtained, in a series of five maze problems, through the use of the Miles Duplicate Maze.

Historical Review

In two independent studies, the coefficients of correlation between maze learning ability and general intelligence range from -0.30 to -0.45.[2] Another study has approached the problem of general adaptive capacity in maze learning by a comparative analysis of the performance of children and adults. In this investigation the conclusion is reached that extreme degrees of intelligence may be handicaps in maze learning.[3]

A study of the relation between intelligence and the ability to solve maze problems is reported by Cox.[4] The Miles Duplicate Maze is presented in a series of five problems of varying difficulty. This situation is not one essentially involving learning; but rather an attempt to measure the intelligence factors

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[1]From the Psychological Laboratory of the University of Pennsylvania. The writer wishes to acknowledge his indebtedness to Professor Edwin B. Twitmyer, Dr. Morris S. Viteles, and Professor Samuel W. Fernberger, and to Dean Charles R. Turner, of the School of Dentistry.

[2]W. S. Hunter, Correlation studies with the maze in rats and humans, *Comp. Psychol. Monog.*, 1, 1922 (no. 1), 37-56; C. J. Warden, Relative economy of various modes of attack in the mastery of a stylus maze, *J. Exper. Psychol.*, 7, 1924, 270-272.

[3]M. C. Gould and F. A. C. Perrin, A comparison of factors involved in the maze learning of human adults and children, *J. Exper. Psychol.*, 1, 1916, 122-154.

[4]C. M. Cox, The intelligence factor in the solution of space problems with the two-story maze, this Journal, 40, 1928, 542-561.

involved in the solution of a relatively new maze problem. The correlations obtained in this earlier study between performance time and the Thorndike College Entrance Test are given in Table I in the report of the present investigation. A qualitative analysis has also been made of intelligence factors involved in these maze problems. Cox suggests that the Miles Duplicate Maze may serve as a valuable performance test of intelligence, if properly standardized.

A number of investigations on the maze indicate the presence of such factors as distractability, temperament, general emotional tone, fatigue, methods of attack, interpretation of problem, which complicate the learning process.[5] Boring, in a study of maze learning with dementia precox subjects, found it advisable to use a paper maze as a preliminary device in order to create a proper attitude and to familiarize the subject with the general nature of the task.[6] Warden, in work with the white rat on the problem box,[7] compared a preliminary adjustment period of 7 initial exploratory trials or standard feeding periods for one group with 7 regular trials of a control group in learning. The results indicate that a period of random activity at the beginning in learning serves to eliminate emotional disturbance, hastens formation of habit pattern, and reduces the total learning time 60%. Methods of extraneous control in learning acts of motor skill are reviewed by Carr.[8] The paper is especially concerned with an evaluation of various forms of 'tuition' (guidance, directions, information, attitude, etc.) and incentive as they are related to the learning process in the maze situation. Perrin also considers various techniques and methods of presentation in learning the stylus maze.[9]

Method

Apparatus. The apparatus, the Miles Two-Story Duplicate Maze, consists of two identical maze patterns, one mounted directly above the other on a wooden box with two open sides. A black cloth fastened to the top platform falls over the open side parallel with *S*'s body, and covers the arm and hand on the bottom maze. The opposite open side gives *E* a full view of the bottom maze.

A small key-piece, an exact replica of the center of the maze, is attached to the top platform and serves as an index to the position of the bottom maze. The lower maze is mounted on a large rotating disk and can be turned to any desired position in reference to the stationary upper maze.

The task involves the movement of a stylus through a visible top pattern, while at the same time another stylus (with a rubber disk to eliminate contact with the maze) is moved through the screened bottom pattern. The path traced through the lower maze is recorded on a sheet of paper placed under the pattern.[10]

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[5]Gould and Perrin, *op. cit.*, 122-154; also Perrin, An experimental and introspective study of the human learning process in the maze, *Psychol. Monog.*, 16, 1914 (no. 70), 36 ff.; Hunter, *op. cit.*, 50-52.

[6]E. G. Boring, Learning in dementia precox, *Psychol. Monog.*, 15, 1913 (no. 63), 51-55.

[7]C. J. Warden, The value of the preliminary period of feeding in the problem box, *J. Comp. Psychol.*, 5, 1925, 365-372.

[8]Harvey Carr, Teaching and learning, *Ped. Sem.*, 37, 1930, 189-218.

[9]Perrin, *op. cit.*, 36 ff.

[10]The top maze was mounted on glass, thus eliminating a scratched surface which would obviously become a disturbing variable. The large disk for the bottom maze had to be set with extra screws around the edge and a special fastener in order to make it more rigid and secure. Four extra studs were also attached to the disk in order to hold the bottom maze more rigidly.

The arrangement of the two mazes and the use of two hands in operation has the advantage of presenting a problem involving the visual, tactile and kinaesthetic senses. This has been classed by Miles as a motor task with maximum indirect visual guidance.[11] The use of cues from one hand to the other, in addition to visual, tactile, and kinaesthetic senses, possibly make the guidance element more complex.[12]

Procedure. The maze task is divided into two parts. The first part is referred to as an 'adaptability' task. The *Ss* are required to trace through 5 successive positions of the maze as quickly as possible. These problems of varying difficulty are obtained by rotating the bottom maze to the following angles in a counter-clockwise direction—0°, 180°, 90°, 180° reverse, and 90° reverse. The last two problems are mirror reversals of the 180° and 90° positions. In presenting the 5 positions of the maze, an attempt is made to test the various abilities and traits that may be evoked in adaptation to the Miles Duplicate Maze situation. In general, the instructions and procedure for the adaptability task follow that of the previous investigators.[12]

After the adaptability task, there is an approximate 5-min. rest interval. In the second part of this experiment one of the above problems (180° reverse position) is given as a 'learning' task. Standard instructions and procedure for the learning task were developed by the present investigator.

The test score in 'adaptability' is based on the time taken, in one presentation of each problem, to trace from the center through to the last exit of the maze. An adaptability problem not solved in 900 sec. was recorded as a failure. In 'learning' the number of trials and the time per trial were recorded. The learning task is finished when two successive trials are made without any retraces and entrances into blind pathways. A detailed record was kept on a standard mimeographed form of the quantitative and qualitative aspects of the performance.

General intelligence. The Psychological Examination (for High School Graduates and College Freshmen), American Council on Education, was used. It was administered, before any maze tests were given, as a group examination.

Subjects. The Main Group of *Ss* for this investigation includes 89 men, students in the Dental School, University of Pennsylvania. All were in the second year class. They had also completed 2 years of a college pre-dental course. A number of them are college graduates and several have pursued graduate and specialized courses. They averaged about 22½ years old and ranged from 20 to 28 years in age.

A second group of *Ss*, 11 in number and hereafter referred to as the Experimental Group, was used in one part of this experiment. This group has a median age of 20 with a range of 17 to 27 years. It consists of 9 men in the undergraduate schools, an instructor, and a college graduate.

Results

(1) Maze adaptability, general intelligence, and chronological age. An examination of Table I, for the Main Group, indicates that the two

[11] W. R. Miles, The two-story duplicate maze, *J. Exper. Psychol.*, 10, 1927, 365-377.

[12] C. M. Cox, *op. cit.*, this Journal, 543-545; Comparative behavior in solving a series of maze problems of varying difficulty, *J. Exper. Psychol.*, 11, 1928 203-206; Miles, *op. cit.*, 371-374.

separate total maze adaptability time-scores and the gross time-scores for each problem correlate insignificantly with intelligence test scores.[13]

TABLE I

CORRELATION OF THE INTELLIGENCE TEST WITH THE TIME-SCORES IN THE VARIOUS MAZE PROBLEMS, AND COMPARISON OF THE RESULTS FOR THE MAIN GROUP OF *Ss* WITH COX'S RESULTS

	Problem				
	0°	180°	90°	180°R	90°R
Main Group	−.18±.07	−.18±.08	−.04±.08	−.19±.07	+.34±.07
Cox's Results	−.26±.06	−.59±.05	−.40±.07	−.11±.09	−.09±.09

	Total Score		
	Gross	Weighted	Av.
Main Group	+.04±.09	+.03±.09	
Cox's Results			−.39±.09

TABLE II

COMPARISON OF TOTAL GROSS TIME-SCORE IN THE FIRST FOUR PROBLEMS WITH THE GROSS TIME-SCORE IN THE 90° REVERSE PROBLEM FOR GROUPS CLASSIFIED IN THIRDS BASED ON INTELLIGENCE TEST SCORE

(70 *Ss*, the odd *S* was grouped in the middle third)

	First four problems			90° R problem		
	Upper	Middle	Lower	Upper	Middle	Lower
Average	726.5	1077.9	949.0	410.8	364.6	242.4
Median	585.0	1047.0	882.0	333.0	401.0	197.0
75% score	426.0	579.0	466.0	185.0	191.0	121.0
25% score	1056.0	1344.0	1206.0	608.0	504.0	322.0
Quartile deviation	315.0	382.5	370.0	211.5	156.5	101.5
Range	342–1290	311–2200	242–2670	97–862	64–806	75–796

The correlation of intelligence test score with performance time on the 90° reverse problem deserves closer examination. Table II shows that the upper third of intelligence has spent less average time than the middle and lower thirds on the first four adaptability problems. But in the last problem (90° reverse position) in which only

[13]A total adaptability score was obtained in two ways. (1) The time scores for each individual on the 5 problems were simply added together. (2) Another total score was obtained by finding the ratio of the S.D. for each problem to the S.D. of the 0° problem. The raw score of each problem was then multiplied by its respective ratio. All the problems are, therefore, given a relatively equal value in the total score. These weighted scores added together yield the total weighted score. The validity of this method was ascertained by correlating the total weighted scores with their respective gross scores for the 55 *Ss* successful in all adaptability problems. This gave a correlation of +0.94, P.E. 0.01. The total scores are referred to respectively as the gross score and the weighted score.

70 *Ss* were successful, the average time score is higher for the upper third of intelligence and lower for the middle and lower thirds. The more time used in tracing the maze in the four positions preceding the 90° reverse problem may possibly lead to greater familiarity with the maze pattern in general; and consequently influences the performance time on the last adaptability problem.[14]

Intelligence test scores may be compared in another way with maze adaptability performance. The number of failures in each maze adaptability problem is tabulated, in Table III, for the intelligence test quartiles. One fact stands out clearly in this comparison. The highest quartile of intelligence has decidedly less failures in all maze adaptability problems.

TABLE III

NUMBER OF FAILURES IN MAZE ADAPTABILITY COMPARED WITH QUARTILES OF INTELLIGENCE TEST

(89 *Ss*, the odd *S* was grouped in the Third Quartile)

	Quartile Rank in Intelligence Test				
Problem	Lowest	Second	Third	Highest	Total
0°	0	0	0	0	0
180°	2	2	1	0	5
90°	7	8	10	1	26
180° R	1	2	1	0	4
90° R	6	5	6	2	19
Total	16	17	18	3	54

The results on the relation of general intelligence to maze adaptability do not, in general, agree with Cox's.[15] The following facts may be of significance in this connection. The Main Group of *Ss* was selected as to intelligence.[16] In maze adaptability, this group is superior in performance to 2 other groups (see Table IV).[17]

[14]Perrin, *op. cit.*, 36 ff. After learning a maze pattern, a change in the position of the maze or a placement of the stylus in various parts of the maze gave little difficulty. The *Ss* were able to adjust to the changes readily, showed signs of familiarity with the paths and the general pattern, and the speed of tracing through the pattern closely approximated, in a short time, the speed for the originally learned maze position.

[15]Cox, *op. cit.*, this JOURNAL, 542-546; also *op. cit.*, *J. Exper. Psychol.*, 206-208.

[16]L. L. Thurstone and T. G. Thurstone, The 1929 psychological examination, *Educ. Record*, 11, 1930, 107-108. When the general intelligence test scores are compared with the larger mixed group of 34,507 cases from 131 colleges, cited in the above reference, the average and median scores of our *Ss* rank above the 75th percentile.

[17]Influence of training appears most important as a possible explanation for any significance that may be attached to the above facts. The *Ss* in the Main Group have had special training, to a very great extent, in tasks involving a variety of motor skills. They have also been trained to explore and to make

TABLE IV

SIGNIFICANT MEASURES BASED ON SUCCESSFUL CASES: COMPARISON OF THE RESULTS OF THE MAIN GROUP, THE EXPERIMENTAL GROUP, AND COX'S GROUP

	Main Group				
Problem	No.	Av.	Median	S.D.	Range
0°	89	67.0	55.8	41.0	20–217
180°	84	217.1	150.0	180.6	33–876
90°	63	420.7	336.0	264.4	56–895
180° R	85	166.4	120.0	136.8	36–698
90° R	70	341.2	300.0	212.4	64–862
Gross total score	55	1054.5	1100.0	416.7	317–1987

	Experimental Group				Cox's Group*	
Problem	No.	Av.	Median	Range	Av.	S.D.
0°	11	51.1	54.0	21–105	96	92
180°	10	337.2	274.0	95–584	361	311
90°	7	596.0	545.0	290–871	463	257
180° R	10	284.2	179.0	42–829	217	179
90° R	7	559.1	561.0	149–850	432	298
Gross total score	6	1720.3	1377.0	1202–2227	—	—

*Consists of 67 college students, 39 men and 28 women.

There is, as is shown in Table V, a low correlation between chronological age and maze adaptability. It reveals a tendency for a lower (better) time score to be associated with a higher chronological age, and vice versa. A consideration of Table I combined with the results in Table V suggests that the degree of success in maze adaptability is favored by a low chronological age and that intelligence is negligible.

A further analysis of the relation of intelligence and chronological age to maze adaptability is found in the comparison of successful and

TABLE V

CORRELATION OF CHRONOLOGICAL AGE WITH TOTAL MAZE ADAPTABILITY SCORE FOR CASES SUCCESSFUL IN ALL FIVE PROBLEMS

	r	$P.E._r$
Total gross time score.....	−.25	.08
Total weighted time score.....	−.25	.09

delicately controlled movements in unseen or limited visual fields with the use of a mirror for work in teeth cavities. However, the available data do not warrant an assumption that any specific transfer or even transfer of general attitudes has directly influenced the results of this group. Correlations of the total weighted adaptability time-score with 8 criteria of technical abiilty in Dental courses range from −0.25, P.E. 0.09 to −0.37, P.E. 0.08.

failure groups (failure in one or more problems). Success as contrasted with failure in maze adaptability appears to be favored by a low chronological age and a high intelligence test score (see Table VI).

TABLE VI

COMPARISON OF THE INTELLIGENCE TEST SCORE AND CHRONOLOGICAL AGE OF THE 55 *Ss* WHO SUCCEEDED IN THE ADAPTABILITY PROBLEMS WITH THE 34 *Ss* WHO FAILED

	General intelligence (in points scored)		Chronological age (in months)	
	Failed	Succeeded	Failed	Succeeded
Average	181.8	193.3	277.7	269.4
Median	182.9	193.3	271.3	267.3
S.D.	44.8	57.2	19.0	17.7
Range	75–268	57–299	244–338	239–317
D/σ diff.		+1.06		+2.05

(*2*) *Maze learning, maze adaptability, general intelligence, and chronological age.* The data that follow present an analysis of the relation between the ability to *solve* a maze problem and the ability to *learn* a maze problem. In the literature, there appears no report of such a comparison of maze learning and maze adaptability with the Miles Two-Story Duplicate Maze or with any similar apparatus.

The 180° reverse position was selected as a learning task following preliminary experimentation with the other four positions of the maze. The problem ranks second in difficulty based on average time score (Table IV). It correlates highest with all of the adaptability problems, with the exception of the 90° reverse position, as shown in Table VII.[18]

TABLE VII

INTERCORRELATION OF TIME-SCORES ON THE FIVE PROBLEMS FOR THE MAIN GROUP

Problem	0°	180°	90°	180° R
180°	+.31 ±.07			
90°	+.18 ±.08	+.22 ±.08		
180° R	+.45 ±.06	+.43 ±.06	+.34 ±.08	
90° R	+.10 ±.08	−.02 ±.08	+.31 ±.08	+.19 ±.08

[18]The general trend and magnitude of these intercorrelations agree very closely with previous findings by Cox, *op. cit.*, this JOURNAL, 545-547. W. T. Heron (Ability *vs.* chance in learning the stylus maze, *Comp. Psychol. Monog.*, 2, 1924 (no. 8), 14-17) reports a similar magnitude of intercorrelations for time scores in five slightly different maze problems that were completely learned. C. L. Hull (*Aptitude Testing*, 1928, 215) says, "While experimental results have failed to show any convincing evidence for distinct levels of abilities, it has revealed what may turn out to be a significant tendency or law, this is that highly complex intellectual activities correlate highly with each other, the less complex correlate to an intermediate degree, and the relatively simple motor activities correlate with each other only slightly."

The low correlations in Table VIII indicate a positive relationship between performance in maze adaptability and maze learning. Group comparisons appear more significant.

TABLE VIII

CORRELATION OF TOTAL TIME-SCORE IN ADAPTABILITY WITH TOTAL TIME-SCORE IN LEARNING

(37 selected *S*s)

	r	P.E.$_r$
Total gross time-score.....	+.11 (+.24)	.11
Total weighted time-score.....	+.19 (+.25)	.11

The total weighted adaptability scores for the select successful group[19] are arranged in rank order and then divided into approximately equal thirds. Comparisons of the maze-learning data are then made possible by distributing the learning scores under these three maze-adaptability sub-groups.[20]

TABLE IX

FIRST PERFECT TRIAL: COMPARISON OF TIME AND NUMBER OF TRIAL FOR THE SELECT SUCCESSFUL GROUP, DIVIDED INTO THIRDS ON THE BASIS OF TOTAL WEIGHTED ADAPTABILITY SCORE

(37 *S*s, odd *S* grouped in middle third)

	Time			Trial		
	Upper	Middle	Lower	Upper	Middle	Lower
Average	41.8	47.9 (49)	59.9 (58)	11.5	11.5 (10)	16.5 (15)
Median	37.0	47.0 (38)	34.0	6.0	7.0	14.0
75% score	15.0	21.0	24.0	2.0	5.0	4.0
25% score	51.0	49.0	67.0	17.0	11.0	23.0
Quartile deviation	18.0	14.0	21.5	7.5	3.0	9.5
Range	14–100	9–149	18–162	1–34	1–26 (24)	1–42

[19]This group of 37 cases has been especially isolated because all the *S*s were successful in both adaptability (all 5 problems) and learning. Whatever relations are revealed between adaptability and learning should appear more clearly with this group, as the conditions of relative and complete achievement were uniform for it.

[20]In examining the various data on learning, the nature of the distribution of the scores and the effect of removing 2 extreme cases may be considered. The total learning times scores are massed toward the lower end of the distribution. Two extreme cases occur beyond the upper range of 3 S.D. These 2 cases fall in the middle and lower sub-groups based on total weighted adaptability score. When these 2 scores are eliminated the differentiation among the three sub-groups in Tables IX, X, XII, and XIII, becomes less distinct. But the indicated general trend in the various comparisons persists. The manner in which the coefficients of correlation are affected by this change is shown in Tables VIII and XIV. Figures in parenthesis indicate the effect of removing the 2 extreme cases.

The various factors in the learning data, in Table IX and X, are consistently differentiated by the above classification. The largest differences appear between the upper and lower sub-groups.

TABLE X

COMPARISON OF TOTAL TIME, TOTAL NUMBER OF TRIALS, AND AVERAGE TIME PER TRIAL FOR THE SELECT SUCCESSFUL GROUP DIVIDED INTO THIRDS ON THE BASIS OF TOTAL WEIGHTED ADAPTABILITY SCORE

(37 selected *S*s, the odd *S* was grouped in the middle third)

	Total time			Total trials			Av. time per trial		
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
Average	831.6	1266.7 (970)	1816.6 (1479)	19.2	23.4	32.5 (26)	50.2	66.9 (62)	79.8 (81)
Median	733.0	881.0 (822)	1425.0	18.0	12.0	24.0	49.0	64.0 (56)	61.0
75% score	623.0	492.0	722.0	11.0	7.0	8.0	31.0	47.0	40.0
25% score	1138.0	1181.0	1875.0	28.0	25.0	43.0	57.0	70.0	95.0
Quartile deviation	257.5	344.5	576.5	8.5	9.0	17.5	13.0	11.5	27.5
Range	251–1698	251–4831 (2481)	370–5526 (3208)	3–35	2–82	4–73 (60)	31–84	16–131 (119)	39–180

In Table XI all of the cases successful in learning are divided into two groups based on performance in adaptability. The group with failures, in one or more adaptability problems, consumes not only longer time, necessarily, in adaptability, but also in learning. This agrees with Table XV, which shows that the failure group in learning was the poorer group in adaptability. As in the preceding data, both Tables XI and XV reveal a positive relationship between performance in maze adaptability and in maze learning.

TABLE XI

COMPARISON OF TIME-SCORES IN LEARNING AND ADAPTABILITY

	Adaptability time		Learning time	
	Success in both	Failure in adaptability	Success in both	Failure in adaptability
	(37 *S*s)	(16 *S*s)	(37 *S*s)	(16 *S*s)
Average	1060.8	2099.1	1301.5	1457.8
Median	1125.0	2182.0	969.2	1168.0
75% score	725.0	1637.0	575.0	763.0
25% score	1300.0	2281.0	1400.0	1931.0
Quartile deviation	287.5	322.0	412.5	583.0
Range	372–1987	1425–2803	237–5526	365–2895

The errors should give information,[21] not revealed in trial and time scores, concerning the relation between maze adaptability and maze learning. In Table XII, the lower third when compared with the upper and middle thirds makes more errors in learning and eliminates errors more slowly as shown by the percentage of cases that complete learning by the 35th trial.[22]

TABLE XII

Comparison of the Select Successful Group, Divided into Thirds on the Basis of Total Weighted Adaptability Score

(37 *Ss*, odd *S* was grouped in middle group)

	Thirds		
	Upper	Middle	Lower
Total no. errors	635	676 (571)	978 (639)
% successful by the 35th trial	100	80 (83.3)	58.3 (63.6)

A more direct presentation of the number of errors eliminated and the rate of error elimination is revealed in Table XIII which shows (1) the total number of errors for every 5 trials, and (2) the ratio, in percentage, of the total number of errors in the first 5 trials to the total number of errors in every succeeding group of 5 trials.

TABLE XIII

Total Number of Errors for Every 5 Trials and Ratio in Percentage of Errors in First 5 to Errors in Succeeding Groups of 5 Trials, for the Select Successful Group Divided into Thirds on the Basis of Total Weighted Adaptability Score

(37 *Ss*, the odd *S* was grouped in the middle third)

	Upper third		Middle third		Lower third		Entire group	
Trials	Total errors	% ratio	Total errors	% ratio	Total errors	% ratio	Total errors	% ratio
1-5	201	100.0	244 (224)	100.0	238 (170)	100.0	683	100.0
6-10	141	70.2	122 (110)	50.0	185 (135)	77.7	448	65.4
11-15	106	52.8	87 (68)	35.7	152 (92)	63.8	345	50.4
16-20	98	48.8	78 (63)	32.0	125 (64)	52.5	301	44.0
21-25	63	31.4	56 (40)	23.0	117 (71)	49.1	236	34.5
26-30	22	11.0	51 (37)	20.9	87 (59)	36.5	160	23.4
31-35	4	2.0	38 (29)	15.6	74 (48)	31.1	116	16.9

[21]The study of errors has been confined to entrance into blind pathways with the exception of one retrace error. This is an elbow turn leading from 6a true path before entering exit path 6. A diagram of this maze pattern is presented by Miles, *op. cit.*, 371.

[22]Only 35 trials of the learning curve have been included, the range of trials is 2-82. The number of trials, however, are representative of the complete learning curve, since 78% of the group (29 out of 37 *Ss*) learned before or at the 35th trial.

The error curve for all sub-groups shows a sudden drop in the first 10 trials. This agrees with the fact that 34% of all the perfect tracings were made in the first 10 trials. The various comparisons indicate that the lower third, slowest in adaptability, makes most errors in learning; has most errors to eliminate; and eliminates errors at a slower rate. The middle third is superior to the upper third up to the 25th trial. At this point the error curve drops suddenly for the upper third.[23]

The coefficients of correlation in Table XIV are low and statistically unreliable. They signify only a possible trend of agreement between lower total learning time (better performance), higher intelligence test score, and higher chronological age.[24] A similar tendency appeared with the data on maze adaptability. But intelligence appears slightly more significant in maze learning than in maze adaptability.

TABLE XIV

CORRELATION OF INTELLIGENCE TEST SCORE AND CHRONOLOGICAL AGE WITH TOTAL LEARNING TIME-SCORE

(37 selected *Ss*)

	r	P.E.$_r$
Intelligence test score	−.25 (−.35)	.10
Chronological	−.18 (−.05)	.11

In Table XV, the successful and failure groups in learning are presented for comparison.[25] The results in this table indicate that

[23]The upper third actually completes learning at the 33rd trial; errors at the 35th trial should be regarded as zero.

[24]E. L. Thorndike (*Adult Learning*, 1928, 106, 155) says, "The general tendency from all our experiments is for an inferiority of about 15% as a result of 20 years from 22 on. Learning representing an approximation of sheer modifiability unaided by past learning shows considerably more inferiority than this. Actual learning of such things as adults commonly have to learn shows considerably less." Experience, interest, caution, care, and organization are important factors possibly favoring older individuals. R. W. Husband (Certain age effects on maze performance, *Ped. Sem.*, 37, 1930, 325-328) found that *Ss* 30 years of age were somewhat inferior in maze learning to those around 20, especially in a comparison of time scores. Gould and Perrin (*op. cit.*, 122-154) discovered that adults whose average chronological age was 21 years when compared with children whose average age was 11 yr. 6 mo., in maze learning made better records in trials, time, errors, and distance traversed. B. H. Candee (The relationship of intelligence and age to efficiency in maze learning, cited in review of literature by S. Y. Liu, The relation of age to learning ability of the white rat, *J. Comp. Psychol.*, 8, 1928, 75) says, "The high school students made better records than did the children from the grades, while the college students were slightly superior to the high school students."

[25]The number of cases varied in parts of the experiment. In learning, 24 *Ss* were used in preliminary experimentation, and consequently are not included in these results.

the failure group in learning spends more time in adaptability; the learning period is decidedly longer in terms of trial and total time; intelligence test scores are lower; and age does not appear significant.

TABLE XV

COMPARISON OF THE RESULTS OF THE GROUPS THAT SUCCEEDED AND FAILED IN LEARNING THE MAZE

	Succeeded (53 *Ss*)			Failed (12 *Ss*)		
	Av.	Median	Range	Av.	Median	Range
Learning time in sec.	1365.0	1042.0	237–5526	2281.1	2123.0	1098–4077
No. trials	26.4	22.6	2–82	56.0	60.0	4–100*
Adaptability time in sec.	1377.7	1300.0	372–2803	1702.9	1696.0	424–3466
Intelligence test score	193.8	191.7	73–299	170.3	161.0	75–247
Chronological age in mos.	270.3	268.1	239–317	268.9	268.0	251–299

*The required minimum for all *Ss* was 30 trials; 2 *Ss* made 4 failure trials (900 sec.) in succession.

(3) *Case study of failures in learning.* This section includes a brief description and analysis of the cases that failed to achieve the learning criterion within a total test period ranging from 2–3 hr. The value of this presentation is manifold. It will present in relief the general nature of the difficulties in this motor problem, the variety of methods of procedure, and the characteristics of the unsuccessful learner. It will also serve to reëmphasize the fact that this motor problem is not a simple trial and error task; but that it evokes a complex response which is indicative of numerous characteristics, traits, and abilities of the individual.

In reading the descriptive and observational data, it is well to recall the quantitative differentiations already made between this group and the successful group in age, intelligence, adaptability, and learning (cf. Table XV).

The 12 *Ss* who failed may be divided into two groups. One, consisting of 8 *Ss*, particularly manifests temperamental, general behavior, and personality characteristics that may account more or less for their failure in learning. A brief summary for each individual in this group follows.

S 1 appeared very tense during performance. There were frequent complaints, "don't see why it won't work," "don't see how one can concentrate," "just sheer luck if I get out of here, I'm using no plan." He seems to lack persistence and planfulness. He was very disappointed in not being able to complete learning satisfactorily.

S 2 criticized and commented on his performance throughout the experiment, "this is hard," "should have watched myself," "upper maze confuses me trying

to keep my mind on lower." He knew that slight entrances were being made into vertical blinds toward body—"don't want to increase time," "disgusted with myself for making foolish errors." He claimed he is too sure of himself.

S 3 appeared very tense and hyperactive. He is easily excited; is the only child in the family. He states that he has a verbal memory defect especially in foreign languages, and difficulty of concentration. He states that he likes to talk about himself freely, but that he is shy and can't make friends easily. This and other 'factors' have been treated by a psychiatrist. During the performance he used profanity in the most abusive manner, appeared very resistive, at times almost to the point of violence; although he wanted to continue the test and give his best performance.

S 4 appeared very distractable, "can't keep my mind on this thing (maze)." He has a lethargic appearance, easily discouraged, wanted to stop work on the maze several times, complained of fatigue in hand frequently.

S 5 stated that he gets nervous in examinations. He appeared disturbed throughout the experiment, and frequently displayed restlessness by shifting feet, shifting body, twisting and turning head. His hands are very large, heavy, clammy, and have a slight tremor. He complained of task, "awful complicated," and had difficulty in coördinating movements at the beginning of the maze pattern.

S 6 stated that he is restless all the time, very fidgety, "can't sit still or read even a good book for any length of time." When an error was made, especially during learning, he would give a general bodily reaction and would ask to be returned to the beginning of the maze.

S 7 is ambidextrous. He appeared very self-conscious and lacks confidence, "I must be a pretty bad specimen." He seemed to lack persistence and ability to initiate, "if I didn't get out of the other one (90° pattern) how am I going to get out of this one (90° reverse pattern)?" "I wonder whether I'm doing what's permissible, orienting myself." (Looked away from top of maze, trial and error on lower maze). "Damned thing doesn't work," (but did not make the next move which would have been correct); seems to have difficulty in attention—"Gee, my mind seems to be off the damned thing." After the experiment he gave several instances of distractability and day dreaming in his everyday activities.

S 8 is also ambidextrous. The natural inclination was toward lefthandedness, and the right hand has been trained. Frequently he must make a conscious decision as to which hand to use in a particular task. He has a special aversion toward changing a daily habit, "develops nausea and gets nervous." Throughout the experiment he appeared nervous, would frequently tense the body, nod the head abruptly, and display facial tics and grimaces.

The remaining 4 *S*s do not give such an overt display of behavior. Two of them made very low intelligence test scores (75 and 96, that is, in the lowest 10% of the Main Group). These data are supported by observation on performance in the maze, which indicated a difficulty in comprehension of task, and a marked trial and error procedure. Both were diligent plodders. One moved very rapidly and the other very slowly.

The other 2 *S*s found difficulty in adopting a method of procedure. One case may be described as failure due to pronounced pressure at the beginning of the maze, very rapid movement, poor coördination, and poor motor control. The other case although displaying a better performance failed to adopt a uniform

method of tracing through the maze.[26] This *S* seemed to have difficulty in utilizing side cues. The performance varied between following the inner and outer sides of the paths. Culs-de-sac were eliminated early in the performance.

Summary

(1) This investigation shows that the ability to solve a maze problem is consistently related to the ability to learn a maze problem.

(2) General intelligence, as measured by a group test, appears more significantly related to the ability to learn a maze problem than to the ability to solve a maze problem (adaptability).

(3) Chronological age is more consistently related to performance in maze adaptability than general intelligence. Success in maze adaptability as contrasted with failure appears to be favored by a low chronological age and a high intelligence test score. But the relative degree of success is influenced by a higher chronological age, and general intelligence is negligible.

(4) General intelligence, performance in maze adaptability, method of procedure, temperament and other personality traits appear as significant factors in the case study of failures in learning.

(5) The results of this study, on the 5 maze adaptability problems, stand in opposition to the earlier results obtained by Cox: (a) significant measures are lower (smaller time-scores); and (b) correlations with general intelligence are negligible, in contrast to relatively higher correlations. However, intercorrelations (among the 5 problems) in the present investigation agree very closely with those obtained by Cox.

[26]Success in learning seems to be dependent upon the formation of a plan for tracing through the maze or an expressed recognition of the nature of the maze pattern. Although no information was revealed as to a particular tracing, there appeared a marked uniformity of response. One method of tracing, which appeared easiest, was adopted by 68% of the *S*s. J. A. Gengerelli (Principle of maxima and minima in animal learning, *J. Comp. Psychol.*, 11, 1930, 227) says, "The essence of the experimental findings is essentially this: an animal, faced with a situation susceptible of an indefinite number of solutions, tends to elect that one which involves the least distance."